

# Appropriate Leads in Electrocardiography

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Before it is possible to assess the significance of any variation in the electrocardiographic tracing, it is necessary to know the appearances of the tracing in healthy subjects. Current practice is to record three standard limb leads, three augmented unipolar limb leads, and upwards of seven chest leads. In this way, minor variations from the normal are likely to be appreciated and more accurate diagnosis can be made in disease of the myocardium.

The innocent nature of certain variations from the accepted normal tracing cannot be overemphasized, because an incorrect interpretation may lead to the premature termination of a career, unnecessary restriction of day-to-day activities, and unreasonable anxiety to the family of the unfortunate victim. It is, therefore, of the utmost importance to establish the significance of these minor abnormalities in the light of our increasing knowledge of the appearance of the normal tracing.

This investigation is concerned with the appearance of certain aspects of the tracing in apparently healthy males, especially with regard to the influence of respiration on the Q wave and the configuration of the S-T segment and the T wave in lead III, the appearance of the T wave in the bipolar CR and the "unipolar" V chest leads, and the possible usefulness of a transthoracic lead.

## SUBJECTS

Two groups of healthy males were examined. Group 1 consisted of 100 youths aged 15 to 16 years who had recently joined the Royal Navy. They were a selected group in that they had recently been found fit for entry into the Service. They varied in height from 61½ in. (157 cm.) to 73½ in. (186 cm.), and in weight from 83 lb. (37.7 kg.) to 188 lb. (85.6 kg.). Nine were under the average for height and weight for their age, and 17 exceeded this average by more than 20 per cent. They were therefore of variable physique.

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Group 2 was made up of 150 apparently healthy adult male officers and ratings aged 20 to 40 years.

In all cases a full-size chest radiograph (teloradiogram) had shown a normal cardiac outline, no single subject had any cardiac complaint, and none showed any clinical evidence of cardiovascular disease, but it is conceded that coronary arterial disease might be causing electrocardiographic changes even at 15 years of age.

## RESULTS

*Lead III and Lead IIIR.* Evans (1951) has stressed the importance of lead III recorded during deep inspiration, and he designated this lead as IIIR where "R" stands for respiration. The lead is often omitted in routine electrocardiography. Evans showed that *in health* the form of IIIR was never the same as in III and that a Q wave of 2 mm. or less in lead III might persist in IIIR, but a Q wave deeper than 2 mm. was never found in IIIR. Moreover, a Q in lead III was not deepened in IIIR, nor would a Q wave appear in IIIR when it was absent in III. He also found that an upright T wave in lead III never became of less amplitude in IIIR nor was the S-T segment depressed except when there was paradoxical movement of the diaphragm; in fact a flat or inverted T wave in lead III might often become upright in IIIR.

*The Q Wave.* The occurrence of a Q wave in lead III and its behaviour in IIIR was investigated in both groups and the results are shown in Table I.

There is a remarkable similarity between the behaviour of the Q wave in III and IIIR in the two groups. It is noteworthy that the Q wave disappeared in IIIR in 42 cases, became smaller in 19 cases, and persisted unchanged in 20 cases (Fig. 1, 2, and 4).

*The S-T Segment and the T Wave.* The behaviour of the S-T segment and the T wave in lead IIIR was also examined. The S-T segment was never

TABLE I

BEHAVIOUR OF Q WAVE IN LEAD IIIIR  
IN TWO GROUPS OF SYMPTOMLESS SUBJECTS

	Group 1 (15-16 years)	Group 2 (20-40 years)	Total
No Q wave in III	67	102	169
Q in III, absent in IIIIR	19	23	42
Q in III, smaller in IIIIR	5	14	19
Q in III, unchanged in IIIIR	9	11	20
Total	100	150	250

found to be depressed in this lead in either group. The results in respect of the T wave are recorded in Table II.

As has already been observed in the case of the Q wave in lead IIIIR, the T wave in IIIIR behaves very similarly in the two age-groups. Twenty-two cases had an inverted and one a biphasic T wave in lead III; on deep inspiration (lead IIIIR) the T wave became upright in 15, flat in 2, and less inverted in 6.

It could be suggested that the change in the T wave in lead IIIIR was related to the degree of expansion of the chest rather than to diaphragmatic movement, but in the 25 subjects in the first group (aged 15 to 16 years) with a chest expansion of at least 3½ in. (8.9 cm.) the T wave was raised in only two cases by more than 1 mm. in lead IIIIR; in 2 of these 25 the T wave was inverted in lead III,

TABLE II

BEHAVIOUR OF T WAVE IN LEAD IIIIR  
IN TWO GROUPS OF SYMPTOMLESS SUBJECTS

	Group 1 (15-16 years)	Group 2 (20-40 years)	Total
T in III upright and similar to IIIIR	50	72	122
T in III inverted; T in IIIIR upright	6	8	14
T in III flat; T in IIIIR upright	4	12	16
T flat in III and IIIIR	4	3	7
T in III inverted; T in IIIIR flat	—	2	2
T in III biphasic; T in IIIIR upright	—	1	1
T less inverted in IIIIR than in III	2	4	6
T in IIIIR taller than in III	34	48	82
Total	100	150	250

becoming upright in lead IIIIR in one and less inverted in the other (Fig. 2 and 4f). Diaphragmatic movement must therefore be the major, if not the only, factor in altering the form of the T wave in lead IIIIR.

*Comparison of V and CR Chest Leads.* In the V leads, incorrectly termed the "unipolar" leads, the indifferent electrode is achieved by joining all three limb leads together, while in the CR leads the indifferent electrode is placed on the right arm. It is the common practice today to record only the V chest leads, though the CR leads have long been shown to demonstrate a more positive deflection.

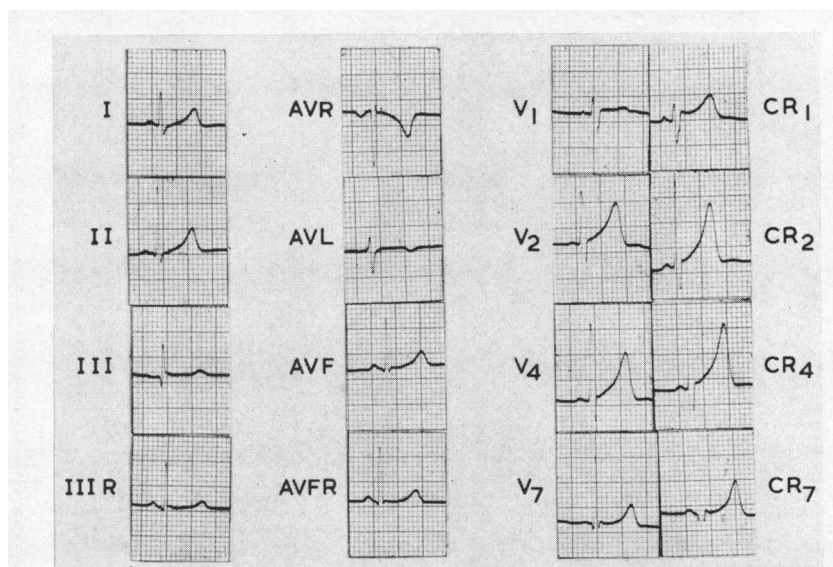


FIG. 1.—Diminution in the Q wave in lead IIIIR compared with lead III, and the increased amplitude of the T wave in the CR leads compared with the V leads in a healthy 16-year-old youth.

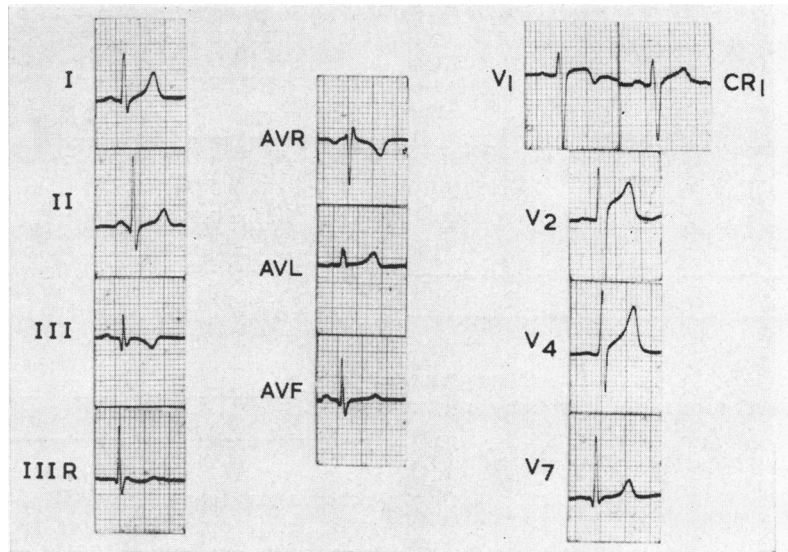


FIG. 2.—Inverted T wave and deep Q wave in lead III altering considerably in lead III R, with an inverted T wave in V1 which is upright in CR1, in a healthy 16-year-old youth.

This aspect was investigated in the 100 subjects of the first group, where it was found that the average height of the T waves was 4 mm. in CR1 and 2 mm. in V1, 7 mm. in CR2 and 5 mm. in V2, 8 mm.

in CR4 and 6 mm. in V4, 5 mm. in CR7 and 3 mm. in V7, confirming that the CR leads almost invariably gave more positive deflections. The same finding was reported by Leatham (1950).

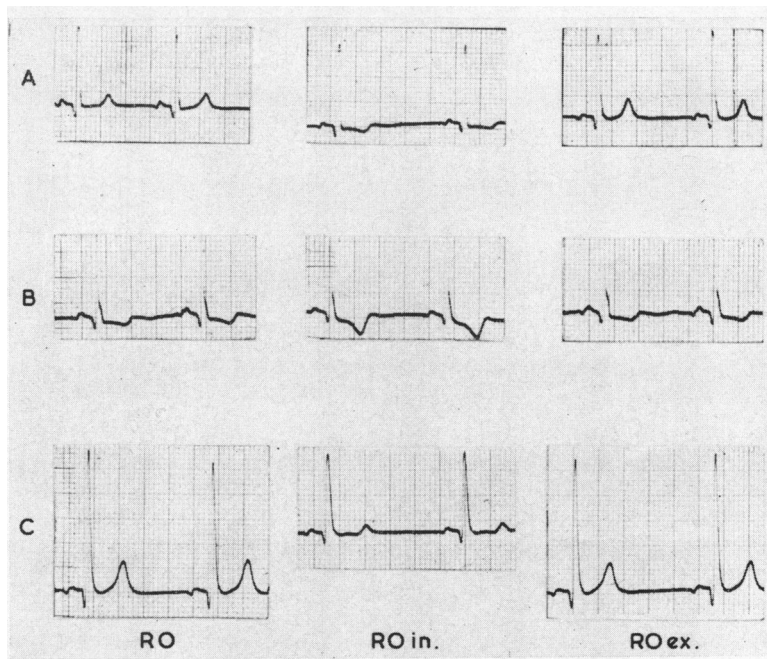


FIG. 3.—The behaviour of the T wave in the right oblique (RO) lead, during inspiration (RO in.), and expiration (RO ex.), in three healthy adults (A, B, and C).

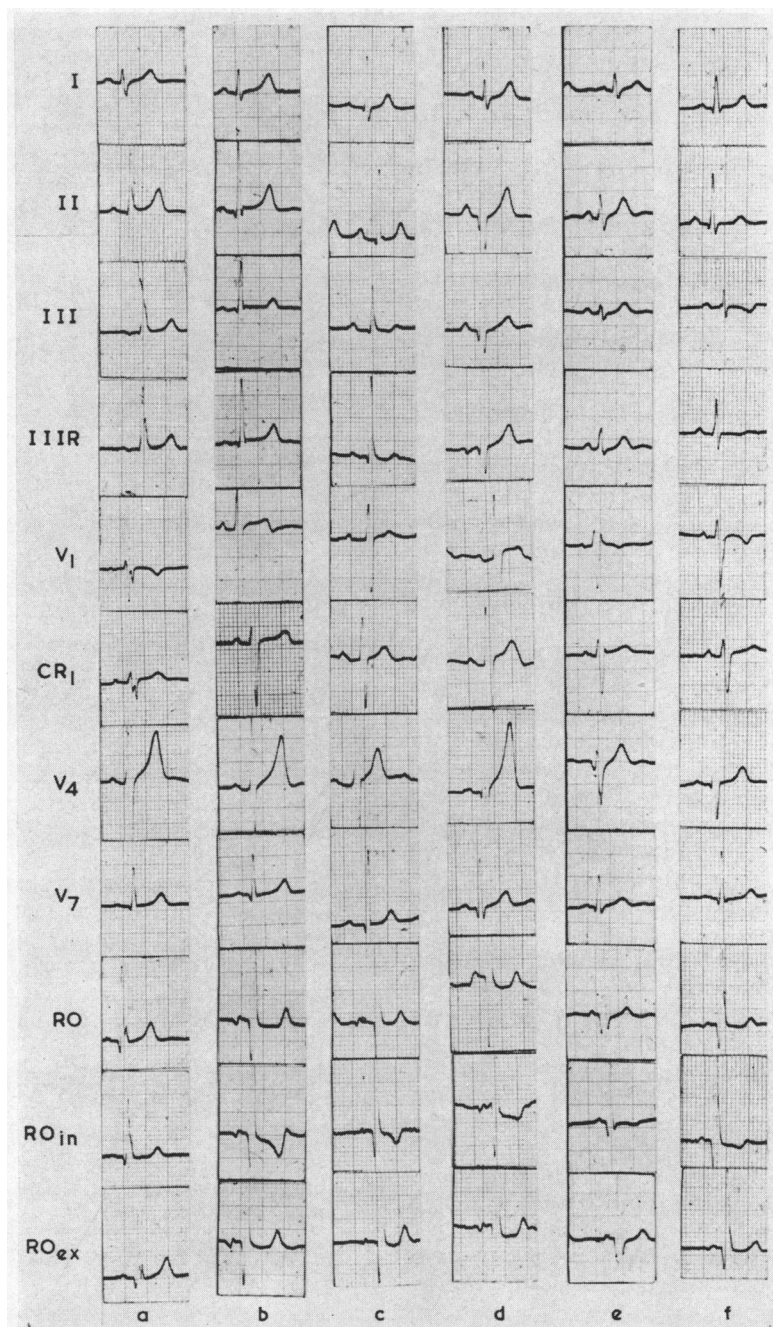


FIG. 4.—Electrocardiograms of six symptomless adults in the second group (aged 20 to 40 years), demonstrating the value of III R (f), the positive deflection of the T wave in CR1 compared with V1 (a, b, d and f), and the varying behaviour of the S-T segment and T wave in the right oblique (RO) lead, RO in inspiration (RO in) and RO in expiration (RO ex). It is noted, however, that the conventional leads in b, c, e, and f do show minor evidence of coronary arterial disease with S-T changes in III and III R (b and c), an abnormal Q wave in V4 (e), and a low voltage T wave in V4 (f).

The CR lead is of particular value in position one (just to the right of the sternum in the fourth inter-space), where the T wave was upright in CR1 but inverted in V1 in 42 among 200 (21%) of the cases examined from this particular aspect (Table III and Fig. 4).

In V7 the T wave was often puny (2 to 3 mm. in height), whereas in CR7 the T wave was more positive (6 to 7 mm.), and in 74 among 200 (37%) the T wave in CR7 was at least twice the amplitude of the T wave in V7 (Fig. 1). The particular value of the appearance of the T wave in CR7 lies in the detection of a small lesion in the postero-lateral area of the left ventricle and in the early diagnosis of left ventricular preponderance.

*Right Oblique Transthoracic Lead.* Evans (1965) described his experiences with the right oblique (RO) lead where the right arm lead is placed in the fourth intercostal space at the right border of the sternum (position one) and the left arm lead in the left posterior axillary line (position seven). In 40 consecutive healthy subjects he found that the P wave in this lead was often of low voltage and sometimes inverted, a Q wave was often present and commonly deep, the T wave often of low voltage but never flat or inverted and the S-T segment was never depressed below the isoelectric line. On the other hand this lead often showed deviation from the apparent normal tracing in cases of myocardial infarction. These findings would be of the greatest importance if they proved to be consistent.

The 100 symptomless adult males aged 20 to 40 years who made up part of the second group were particularly investigated as to the form of the RO lead tracing, and it was observed that in certain cases the T wave varied in shape during respiration so that it was often depressed in full inspiration (Fig. 3). Moreover an inverted T wave not only occurred in health, but it could become upright in full expiration. An inverted T wave in the RO lead was found in 39 of the cases, and in 3 of these it became upright in full expiration. Conversely, an upright T wave in RO in 61 cases became inverted in 18 during inspiration. The appearance of the T wave in the RO lead is, therefore, so variable in health that it cannot have great diagnostic value, though Evans (1965) states that a positive T wave in the RO lead would exclude a myocardial lesion

TABLE III  
POSITIVE OR NEGATIVE DEFLECTION OF  
T WAVE IN V1 AND CR1 IN SUBJECTS  
OF GROUP 1 (AGED 15 TO 16 YEARS)  
AND IN 100 SUBJECTS OF GROUP 2  
(AGED 20 TO 40 YEARS)

	Group 1 (15-16 years)	Group 2 (20-40 years)	Total
Inverted T in V1; upright T in CR1	21	21	42
Inverted T in V1; flat T in CR1	4	1	5
Inverted T in V1 and CR1	—	5	5
Flat T in V1; upright T in CR1	3	—	3
Upright T in V1; taller in CR1	68	73	141
Similar and upright T in V1 and CR1	4	—	4
Total	100	100	200

when changes in leads III, IIIR, and CR7 are inconclusive.

#### CONCLUSIONS

This investigation has upheld the usefulness of lead IIIR in routine electrocardiography, so that it should become the fourth standard lead.

The CR leads are to be preferred to the V leads for routine use, since the amplitude of the T wave is greater in CR than in V leads. Negativity of the electrical potential in V leads in right-sided chest leads and especially in left-sided chest leads might be regarded erroneously as indicating myocardial disease.

The right oblique transthoracic lead (RO) shows no consistent configuration in symptomless subjects and is not by itself of value in the diagnosis of myocardial ischaemia, though when there are questionable changes in leads III, IIIR, and CR7, a positive T wave in RO excludes ischaemia.

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